WHAT IS CLAIMED IS:

1. A crystallization apparatus comprising:

a light source which emits a light beam;

a mask which receives the light beam from the light source and makes an intensity distribution of the light beam into an inverse peak pattern that a peak value has a minimum intensity; and

an image forming optical system which is positioned between the mask and a processed substrate, and forms an image of the light beam having the inverse peak pattern on the processed substrate, thereby crystallizing at least a part of a substance of the processed substrate.

2. The crystallization apparatus according to claim 1, wherein the mask has a phase shift mask in which adjacent areas have different thicknesses and a phase shift portion having a step between these areas is defined.

3. The crystallization apparatus according to claim 2, wherein the a phase difference of the phase shift portion of the mask is 180° so as to produce a peak value of which the intensity is substantially zero.

4. The crystallization apparatus according to claim 1, further comprising a support which supports the processed substrate at a defocus position separated from a focal position of the image forming optical

system by a predetermined distance.

5. The crystallization apparatus according to claim 1, further comprising a support which supports the processed substrate at a focal position of the image forming optical system, wherein the image forming optical system has an aperture whose NA can be changed so as to be capable of adjusting a width of the inverse peak pattern.

6. The crystallization apparatus according to claim 5, wherein assuming that λ is a wavelength of the light beam and NA is a numerical aperture of the aperture, a width D of the inverse peak pattern is given by the following expression:

$D = k\lambda/NA$ (k is a value from 0.5 to 2).

7. The crystallization apparatus according to claim 1, further comprising a support which supports the processed substrate at a focal position of the image forming optical system, wherein the image forming optical system has a pupil which sets a two-stage peak pattern having a first pattern positioned on a side where an intensity is low that an inverse peak pattern has a peak value, a second pattern positioned on a side where the intensity is high, and a step portion positioned between the first pattern and the second pattern so that a width of the first pattern is greater than a width of the second pattern.

8. The crystallization apparatus according to

claim 7, wherein the pupil of the image forming optical system has a light transmission area and a light semi-transmission area surrounding the light transmission area and, assuming that D1 is a width of the first pattern of the two-stage inverse peak pattern, D2 is a width of the second pattern of the same, θ1 is a diameter of the light semi-transmission area represented by an angle and θ2 is a diameter of the light transmission area represented by an angle, a size of a distribution of an outgoing radiation pupil function of the pupil of the image forming optical system satisfies the following expressions:

$D1 = k\lambda/\sin\theta 1$ (k is a value from 0.5 to 2)

$D2 = k\lambda/\sin\theta 2$ (k is a value from 0.5 to 2).

9. The crystallization apparatus according to claim 1, wherein a mask pattern of the mask has a phase shift mask having an intersection consisting of at least three or more phase shift lines and an integral value of a complex transmittance of a circular area with the intersection at the center being substantially zero.

10. The crystallization apparatus according to claim 9, wherein each of the three or more phase shift lines has a phase difference being less than 180 degrees (π).

11. The crystallization apparatus according to claim 9, wherein the number of phase shift lines is

four, and each of the phase shift lines has a phase difference of substantially 90 degrees.

12. A crystallization method comprising:

generating an inverse peak pattern having a peak value that a light intensity is substantially zero at a phase shift portion of a phase shift mask by using this mask; and

irradiating a processed substrate with a light beam having the inverse peak pattern, thereby crystallizing at least a part of a substance of the substrate,

wherein an image of the light beam of the phase shift mask is formed on the processed substrate by using an image forming optical system provided between the phase shift mask and the processed substrate.

13. The crystallization method according to claim 12, wherein an image of the light beam is formed with the processed substrate being held at a defocus position separated from a focal position of the image forming optical system by a predetermined distance, thereby achieving crystallization.

14. The crystallization method according to claim 13, wherein the processed substrate is held at a focal position of the image forming optical system, and

a width of the inverse peak pattern is adjusted by changing NA of the image forming optical system, and

an image of the light beam is formed on the processed substrate, thereby achieving crystallization.

15. The crystallization method according to claim 12, wherein the processed substrate is held at a focal position of the image forming optical system, and

the inverse peak pattern is made into a two-stage inverse peak pattern in such a manner that an outgoing radiation pupil function of the image forming optical system becomes a sum of two types of large and small distributions of an outer area and an inner area, and the processed substrate is irradiated with the light beam, thereby achieving crystallization.

16. A phase shift mask for a light beam, wherein a mask pattern has an intersection consisting of at least three or more phase shift lines, and an integral value of a complex transmittance of a circular area with the intersection at the center is substantially zero.

17. The phase shift mask according to claim 16, wherein each of the three or more phase shift lines has a phase difference being less than 180 degrees (π).

18. The phase shift mask according to claim 16, wherein, when the number of three or more phase shift lines is four, a phase difference of each of the phase shift lines is substantially 90 degrees.

19. A phase shift mask for a light beam, comprising:

at least two phase areas having different phases; and

a boundary line defined between the adjacent phase areas, and a light shielding area formed in one phase area along the boundary line.